ist Engin.
Library
TN
23
U581c

JUN 2 3 1929

CIRCULAR 6136 MAY, 1929

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

PROGRESS IN METAL MINE VENTILATION

BY

D. HARRINGTON

Digitized by Google

Circular No. 6136
May, 1929.

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

PROGRESS IN METAL MINE VENTILATION[1]

By D. Harrington[2]

Correct ventilation of underground workings whether in coal or in metal mines consists in establishing such control of air currents that the miners may work in safety, with maximum comfort and efficiency, and without impairment of health; also in controlling the air flow so that the mine workings may at ordinary times be kept reasonably free of harmful gases or dusts, and so that in time of emergency, as when a fire or an explosion occurs, there may with minimum delay be maintained as much or as little air flow as is desired throughout the mine in its entirety or in certain parts of the mine.

Control of air flow is the essential point of any mine ventilating system, and is obtained only by the installation of mechanically operated fans, and other ventilating devices such as doors, overcasts, regulators, etc. Every mine, large or small, coal or metal, should from the outset be equipped with a fan. Much has been written about natural ventilation, and many claims have been made that in specific mines or parts of mines there is sufficient natural air flow. As a matter of fact, there are actually very few if any mines, coal or metal, where natural ventilation creates atmospheres anything like adequately safe or healthful for underground workers even at ordinary times or under ordinary conditions; and at the time of a fire or an explosion mines depending upon natural ventilation are practically helpless, and are decidedly dangerous for the unfortunates forced to be in them either at the time of the disaster or afterwards when trying to handle conditions arising from the emergency.

Coal mines are usually compelled by State law or by existance of explosive gas to establish some sort of ventilating system, but most metal mines rarely pay any particular attention to air flow until forced to do so by some unusual circumstance or by unfavorable underground working conditions. State or other laws as to ventilation of metal mines are practically nonexistent, and the few laws on the statute books of the various States of the United States concerning ventilation of metal mines are essentially meaningless; at best they, like the State laws as to coal mines, are woefully crude and inadequate. Notwithstanding this, there is annually some progress made in metal-mine ventilation, and the year 1928 has produced at least a slight amount of data which should be of aid in forwarding ventilation betterments in metal mines.

---

1 This paper was presented at the February, 1929, meeting of the American Institute of Mining and Metallurgical Engineers. The Bureau of Mines will welcome reprinting, but requests that the following footnote acknowledgment be used: "Printed by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.)"

2 Chief Engineer, Safety Division, U. S. Bureau of Mines.

Digitized by Google

Cooling of Mine Air

Much has been written during 1928 concerning the many problems associated with the desirability, in some cases the absolute necessity, of cooling the air in working places in some of the most productive mines - gold, silver, copper, iron, and other metal mines, as well as coal mines. As in the past, most of the data concerning developments in the cooling of mine air have come directly or indirectly from foreign countries and particularly from South Africa.

The following abstract from the 1927 Report of the Government Mining Engineer of South Africa indicates that in mines which are rated as hot, not only the efficiency but also to an increasing extent the very lives of the underground workers must depend upon the finding of some efficient method of cooling air.

> Deaths from heat stroke for the year 1927 totalled 8, as compared with 6 during the latter portion of 1926. This class of accident was first included in the accident statistics in August, 1926, when it was decided that such casualties were directly due to the conditions under which the persons affected had to carry on their occupation, and were likely to increase as the mines became deeper.
>
> As the workings have become deeper and the rock temperature higher, it has become apparent that more elaborate and systematic ventilation arrangements are necessary. It has always been known that the efficiency of the worker becomes less as the temperature and humidity increase, and now that deaths have occurred amongst some workmen and others have been temporarily incapacitated, the urgency for improved ventilation and cooling of working places has been realized. It is evident that, unless this matter is dealt with satisfactorily in the future, the decreased efficiency of the workers will result in an increase of working costs and consequent restriction of operations.
>
> It is also generally recognized that, as the temperature and humidity increase, the hazard of accident becomes greater, owing to lowered vitality of the individual and dulled reaction to a sense of danger.
>
> Serious attention is now being given to the above matter, and notable improvements in some of the mines are already apparent.

In the same report, pages 66 and 67, are the following details concerning some of the essential conditions surrounding the workers, and also a description of the working conditions where the cases of fatal heat stroke occurred.

> Four deaths of natives from heat apoplexy were reported, all from the City Deep. In the previous year there were seven such deaths, of which six were at the Village Deep and one at the City Deep.

Digitized by Google

The fatal cases at the City Deep were all among natives who were not thoroughly acclimatized. Two of the deceased were working their second shifts in the mine; one was working his third shift in the mine and his first at the place where he was overcome; and one was working his fifth shift in the mine and his first at the place where he was overcome.

If the record is examined in another way, it is found that two were working in probationary gangs, and one had just been removed at his own request from a probationary gang in which he had worked four days, as a few days before he had been working underground at another mine. One of the deceased had not been placed in a probationary gang. His case was the first during the year, when the organization for acclimatization was faulty.

Records supplied by the mine, showing approximately what the conditions were at three of the places where the fatalities were caused, may be placed on record. They are--

(a)	Kata-thermometer ...	11.0	wet	3.88	dry
	Hygrometer	86.5°F.	wet	87.0° F.	dry
(b)	Kata-thermometer ...	9.65	wet	2.29	dry
	Hygrometer	84.6°F.	wet	85.2° F.	dry
(c)	Kata-thermometer ...	5.4	wet		
	Hygrometer	90.0°F.	wet	90.5° F.	dry

Two of the deaths occurred in March, one in April, and one in November.

The absence of deaths at the Village Deep during 1927 was doubtless in part due to the precautions outlined in my last annual report, which include probationary or acclimatization gangs for new natives, salt in drinking water, and meals underground; and perhaps also was partially due to injections of a preparation named "Lobelin" when symptoms of danger were noticed, but it was mainly due to the improved ventilation produced by the more powerful ventilating fan installed during 1926.

Six nonfatal cases of collapse due to heat were reported from the City Deep, and two such cases from the Village Deep. The cases at the City Deep included an instructor and four apprentices in the Government Miners' Training School section. These are the only cases among Europeans yet reported. It was ascertained that each of the five persons was in either the inception or convalescent stage of mumps at the time of his collapse.

From the foregoing description it would appear that the fatalities occurred in practically saturated air with temperatures between 85 and 91° F.; such temperature and humidity conditions are to be found in a considerable percentage of the working faces in many of the deep metal mines of the United States.

In the Mining Magazine of London of September 28, 1928, is the following description of the use of ice in cooling working places in the Boulder Perseverance gold mine of Kalgoorlie, Australia, the ice supposedly serving the double purpose of cooling the working place and of aiding in some manner in the allaying of the fumes and possibly the dust left in the air from blasting:

Digitized by Google

Ice in Blasting.- In the Kalgoorlie Mine for July 4, Ernest Williams, manager of the Boulder Perseverance gold mine, gives some particulars of his experience with ice for cooling mine air at the time of blasting for the purpose of accelerating the removal of fumes from the atmosphere.

Fumes and high temperatures have always been sources of trouble and expense in mining development work at Kalgoorlie. Mr. Williams and his staff have evolved a new scheme, the use of ice, to overcome these drawbacks, and the successful results achieved by them will materially reduce the cost of winzing and work in development ends. In May, 1927, Mr. Williams, in order to reduce the amount of time lost in waiting for fumes to clear from winzes (sometimes up to two hours in deep winzes) tried the device of throwing ice into the winze to clear the atmosphere. Finding that the ice had the desired effect, he developed the idea and the present practice is to break up about 50 lb. of ice into 6 in. pieces and throw it down immediately after firing. The cold condenses the fumes and forces out the hot air and the men are able to return to the bottom of the winze 40 minutes after firing. As far as it is known, ice has never been used in this manner before, though ice has been used in South Africa and parts of America to cool the main air currents in the ventilation system.

The procedure in using ice in drives or cross-cuts is somewhat different. This scheme was first tried in September, 1927, and after a time it was found that the most successful method was to place the ice in a box, specially designed, and connect up a 2 in. compressed-air pipe. The ice-box holds approximately 60 lb. of ice when charged and 1 cwt. of ice is consumed in a shift. The ice-box is placed about 80 ft. away from the face and the cool air is taken through an outlet pipe and discharged 15 to 20 ft. from the face. As soon as the fuses are lighted the cool air is turned on, and 30 minutes after firing the atmosphere is clear, and the wet and dry bulb temperatures well below the mark set by the Arbitration Court. The margin between the wet and dry figures, as shown in the accompanying table, indicates the effect of this use of ice. The table is a record of temperatures taken in advancing four cuts at the 1,100 ft. level of the Perseverance on the X lode north drive. The readings were taken between May 24 and June 4, 1928. The ice-box was used only during firing. The temperatures before firing were taken with the icebox shut off. Each cut was approximately 5 ft. and 30 minutes after firing the atmosphere was clear. Temperatures as shown in the table were then taken and work was resumed.

TEMPERATURE FAHRENHEIT

	Before firing		First firing		Second firing		Third firing		Fourth firing		Fifth firing	
No. of cut	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
No. 1 Face	77½	75¼	76½	73½	78½	75	78	73½	78	73½	--	--
No. 2 Face	76½	73½	76	73	77	74	78	74	78	74	--	--
No. 3 Face	76	73	77½	72½	78	73	78	73½	78	72	--	--
No. 3 Face	78	71½	--	--	--	--	--	--	--	--	76	70
No. 4 Face	78	75	78	74	77	73½	77	70	77	71	78	71

Digitized by Google

Apparently metal mining companies in South Africa and Australia are using ice to a considerable extent with the idea of making underground temperatures endurable for workers in contact with hot rock.

In the South African Mining & Engineering Journal, issue of August 18, 1928, was presented the following rather optimistic forecast as to a probably effective method of locally cooling hot humid air in deep working faces:

As anticipated in these columns some months ago, a solution of the problem of working in high temperatures in the deep level mines of the Rand seems now in sight owing to the successful research work done by some of our leading engineers. The invention in question is a portable air cooler which claims to be an economic solution of the difficulties met with in a hot humid atmosphere. The mines on the Rand are particularly free from natural, dangerous or poisonous gases, and, with modern ventilating methods and single-shift working, bacteriological or chemical contamination is practically unknown. We have only to contend against heat and humidity, because, outside these factors, the air is good and suitable. The problem, therefore, resolves itself into cooling the air at any particular working place and extracting the moisture. The underlying idea in the new apparatus is that certain sections of a mine are treated as independent units. The ordinary ventilating current in each section of convenient size is improved by removing moisture and cooling the air by taking advantage of the cheapest available sources of power and cooling mediums and utilizing these in a combination of machines and devices, which can serve any selected section. When a section is worked out, the machine can be removed to another section. The principles involved are:--1. The compression of warm, saturated mine air sucked into the machine from any section of the mine. 2. The cooling of the compressed air to about its initial temperature by circulating mine water. 3. The extraction of the moisture condensed during the cooling process whilst at high pressure. 4. The expansion of the high pressure air in an air motor so that a low final temperature is obtained and the dry air discharged to working places. The power developed by the air motor is utilized to assist in driving the compressor. 5. Reheating the cold expanded air by stages, so as to prevent troubles due to very low temperatures and to reduce the power consumption by utilizing the circulating water passing from the coolers during or after compression of air. 6. The balance of power required to drive the compressor not furnished by the air motor and making up frictional and other losses to be supplied by an electric motor. Such a machine as herein outlined has not yet been built, but it seems fairly evident that it offers a plausible and possible solution of the heat and humidity problem in ultra deep-level mining, because of three prominent factors. 1. Cheap electrical power supply available underground. 2. The production of localized cool and dry air without any undue heating of the mine, because a comparatively small quantity of water is required and warmed up but a few degrees, so that in nearly all cases the seepage water in the mine (which must in any case be pumped to the surface) will suffice to cool and dehumidify the air at selected places with very little extra expense in pumping. 3. It is also probable that the capital cost will be moderate, as it

Digitized by Google

is not necessary to dehumidify and recondition the full ventilating current of a mine, but only to deal with the air used in the sections where active work is being carried on. In a recent discussion on the subject, Mr. W. Elsdon Dew said that in an endeavor to analyze the theoretical considerations and to put to practical use the proposed methods, an enquiry had been issued to certain manufacturers who would be able to design and manufacture a machine to suit the conditions laid down. If a suitable machine at a suitable price could be provided, a practical test could then be carried out. The experiment was worth a trial, and only by such an experiment could progress be made. The industry as a whole is, of course, vitally interested in the matter, and we hope to chronicle at a later date the progress being made.

In the United States attention is being more definitely directed to the problem of mine-air cooling and conditioning. The following paragraph from the National Coal Association Bulletin of September 15, 1928, brings to the fore some underlying principles of refrigeration which in some form or other may be applicable to cooling mine air:

Attention is directed to a new type of iceless refrigerator cars, the operating principle of which is based partly on the compressed gas system used in lighting passenger coaches. A supply of gas is carried in fuel tanks under the car. Burners are lighted and are extinguished automatically at intervals. A hard, glassy substance, with the appearance of clear quartz and capable of absorbing a large amount of moisture is used. This material is called silica gel and is heated by the burners. The ceiling of the car is piped with sulphur dioxide as the refrigerant. It is circulated by the physical action of the absorption and the driving out of the vapors from the silica gel. The first twenty-five of these cars are in service. It is stated the temperature can be set and maintained for an entire trip, with but little variation. Thus we have the forerunner of what may prove to be a revolution in refrigerator-car service.

There also appeared the following item in the September 4, 1928, issue of Power, published by the McGraw-Hill Publishing Co.; here again is described a method of air conditioning for offices in surface buildings which might with suitable modification be applied to the local conditioning of air at faces in mines having hot and humid but otherwise pure atmosphere:

It is stated that a Carrier air washer and a Brunswick and Kroschel 3-ton carbon dioxide refrigerating machine and other equipment were installed to ventilate an office which might contain about 60 men and women, and in order to secure the delivery of 30 cu. ft. of air per minute per person a fan with a capacity of 2,000 cu. ft. of air per minute was installed. The air was passed vertically through a fine spray of water which, besides cleaning it, cooled it to about 55°F. The consumption of electricity by the refrigerating plant was about 14.3 kw. per hour.

Digitized by Google

There is no question that cooling of mine air is a live subject in connection with the safe and efficient working of many of our metal mines; although application of some form or forms of local cooling or refrigerating or conditioning of air will undoubtedly be necessary in some mines or under some circumstances, nevertheless the most effective remedy to date for the "conditioning" of air at working faces or places in mines is the continual circulation of relatively large volumes of fresh pure air from the surface to and past the places where men work. This means that the best remedy for the relief of hot humid air in mines is the installation and operation of an adequate ventilation system.

Dust and Dust Disease in Metal Mines

For some years it has been recognized that one of the most effective methods of combatting the dust menace in metal mines is the continual coursing of currents of fresh air to and then away from the places where men work - usually the places where the dust is most harmful in quantity and quality. Although little is heard concerning the health hazard from dust in mines, the hazard continues to exist; and although some alleviating methods and practices have been installed and used in many of our more progressive metal mines - practices such as extension of ventilation, use of wet drilling, use of water sprays, water blasts, etc., shooting largely if not wholly at the end of the shift, etc. - nevertheless both in the United States and in other countries which use much more drastic methods than we do for prevention of mine-air dustiness and of dust disease of mine workers, there continue to be much silicosis and other kindred diseases due largely if not wholly to dust.

There is a well-defined tendency to believe that the only dust which is dangerous to inhale is that which is composed largely of silica, especially of free silica. That this is a dangerous fallacy was plainly shown by a study of the effect of dust inhalation on cement workers as reported in Bulletin 176 of the U.S. Public Health Service in 1928. The results of this study indicated that silica constituted less than 25 per cent of the dust and that of this amount of silica only a very small portion was free silica - the material generally held essential for harmfulness from dust. However, breathing large quantities of the very finely divided dust caused the cement workers to have nearly three times the absentee record from colds, bronchitis, influenze, and grippe; resulted in skin diseases causing five times as much disability; and also brought on diseases of the eyes, ears, pharynx, tonsils, and rheumatism three times as often as among workers of the same age-range in a rubber plant of similar size and number of employees. It was found that a large percentage of the workers voluntarily left the industry because of its ill effect of one nature or other on the health, thus leaving in the industry those whose powers of resistance were inherently higher than the average. It was also found that about one-third of the workers who had been employed three years or longer had one or more respiratory defects or chronic respiratory diseases. Of 37 X-rays taken, 15 showed dust disease of the lungs, 3 showed tuberculosis, and 8 others showed more or less evidence of tuberculosis. It was definitely concluded that one of the main problems of the cement industry is dust control; this decision is the more significant from the viewpoint of the

Digitized by Google

metal-mining man in that the dust had little or no free silica and that much more than 50 per cent of the dust was lime, which has heretofore been considered by many authorities to be harmless and by others to have remedial rather than harmful effect when breathed from the air. The application of this conclusion to the mining industry means that any or all finely divided dusts in the air and in large quantities when breathed for considerable periods daily are likely, in fact almost certain, to be harmful; hence all dusty methods, processes, or practices in metal mining should be eliminated or at least limited. The best methods of doing this are the exclusive use of wet drills in drilling, the postponement of blasting of all kinds until the end of the shift or after the regular shift, and the use of continuous air currents to and past working regions or other dust-producing places to keep the finely divided dust out of the areas where men must work.

In view of the long-continued systematic and expensive fight waged against silicosis and other dust diseases in the metal mines of South Africa, the following editorial which appeared in the South African Mining and Engineering Journal on August 25, 1928, is of more than usual interest; the article indicates that even when virtually all known methods of prevention are placed in effect, many of them of a far more drastic nature than even thought of in the United States, the dust diseases (silicosis, tuberculosis, etc.) are by no means eliminated.

> We have not got rid of silicosis, but I believe, as I have said, that we have turned a big corner in the matter. Dr. Irvine draws attention to the different way in which Europeans and natives are affected by the two risks, dust and tuberculous infection. "Of all cases of compensatable disease--under which term one includes the three clinically distinguishable conditions of "simple silicosis," "tuberculosis with silicosis," and "simple tuberculosis,"--of all such cases which occur in European mines, over 88 per cent are at the outset cases of clinically simple silicosis. A little over 6 per cent only have active simple tuberculosis or obvious tuberculosis along with silicosis when first detected. These are the data for the last two years taken as a whole. Amongst mine natives, on the other hand, the position is reversed. Over 83 per cent of all cases of compensatable disease in natives are obviously tuberculous, and more than half of the total are cases of active simple tuberculosis. Simple silicosis accounts for only 16 per cent. There are also data for the last two years. Compared with what we know of European communities, the prevalence of tuberculosis amongst the mine natives is not exceedingly high. But, in the gross, cases of active simple tuberculosis or of active tuberculosis with silicosis totalled in the last year nearly 1,200, each a potential source of infection of others and of European miners. What one feels is that miners' phthisis has, in the past, been apt to be viewed by technical men too much as simply a dust question, and not enough as a question of tuberculosis." The necessity for the fullest possible control of native tuberculosis is stressed but the author concludes: "I feel more hopeful about miners' phthisis than I have felt for many a long day. But that hope should encourage us all the more to push on with the job, so that all the time we may do better and better. With increasing depths and temperatures the problem is not growing easier. But people look to us here on the Rand for instruction in the best practical

Digitized by Google

methods for the control of this industrial disease which is a menace to many mining communities the world over. And they are coming here in 1930 to learn how."

Mine Fires

Metal-mine ventilation and metal-mine fires are so closely related that any extended reference to one of them almost necessarily brings the other into the discussion. The Hollinger fire on February 10, 1928, in the great Porcupine gold mining district of northern Ontario was the outstanding metal-mine fire of the year, and was also the first extensive metal-mine fire in point of loss of life in the history of metal mining in Canada; 39 lives were lost, though the property loss was trivial. The fire stunned the metal mining men of Ontario, as they had been of the opinion that these mines were essentially immune to fire. This attitude is only too prevalent among metal mining men throughout the world; not until it is realized that any and all metal mines, even those which are essentially wet, have a definite fire hazard will there be a cessation of the metal-mine fires causing loss of life out of all proportion to the amount of the fire itself.

Practically all metal mines have combustible matter in and about them in the form of timber, explosives, oil, etc., which when burning may readily give off fumes of such poisonous nature as to snuff out lives by the score. The material which burned and gave off poisonous fumes sufficient to kill 39 underground workers was chiefly débris from explosives boxes, sawdust, etc., that had been thrown into a nearby stope - a practice which has been more or less prevalent (and one whose probable dangers would be, in fact have been, on numerous occasions, scornfully minimized) in metal mines not only in Canada but in various parts of the United States. The total amount of combustible matter was small, but the fumes given off in the confined passages of the mine were deadly. In 1928 a fire in a metal mine in Mexico resulted in the death of over 20 men, yet the total amount of charred underground mine timbers (little or none of them absolutely burned) amounted to less than 3 cords.

Unfortunately practically all metal mines have in them not only enough combustible matter to burn with attendant heavy loss of life under some circumstances, but also practically all have readily available the flame to ignite the combustible matter. The igniting flame is generally from open lights, almost in universal use in metal mines, from tobacco, matches, and other smoking materials, and from electricity; the dangers from arcing and sparking are intensified through the unsafe electrical installations and practices almost universally prevalent in metal as well as in coal mines. Also the numerous (almost innumerable) dangerous practices in handling explosives, including dynamite, fuse, and detonators, in metal mines give an almost ever-present source of flame for ignition of any incombustible matter which may be within reach.

Probably the Hollinger fire with its 39 fatalities was started by an open light; the Granite Mountain fire in Butte, Mont., in 1917 with 163 fatalities was caused by an open light; the Magma fire in 1927 with 7 fatalities was probably also caused by an open light, possibly a cigaret; and there have been numerous

Digitized by Google

other metal-mine fires in late years due to open lights or smoking. In fact, open lights have been the igniting cause of more metal-mine fires during the past 10 years than any agency except electricity; and there will continue to be periodical metal-mine fires with disastrous loss of life until metal mining men realize that open lights not only are dangerous but also are less efficient, less safe, and less economical than the safe-sane up-to-date types of storage battery electric cap lamps.

Subsequent to the Hollinger disaster Judge Godson, who was appointed by the Province of Ontario to conduct an inquiry into the disaster, made two reports, and in the final one he made a number of recommendations after having taken volumes of testimony from miners and mining men not only at the Hollinger mine but also at other representative properties of the Province. The recommendations of Judge Godson in a report dated September 28, 1928, are as follows:

I recommend that the Mining Act of Ontario governing the operation of mines be amended by varying or adding thereto in substance the following submissions:-

1. That every man employed as an underground foreman, (meaning thereby one who is exclusively engaged in supervising the work of other men), shall be able to give and receive orders in the English language.

2. That an Inspector of Mines shall have the right to suspend any foreman or mine captain who is not familiar with or does not understand the requirements of the regulations governing the operation of mines as contained in the Mining Act of Ontario.

3. That the words 'above ground' in the first line of Section 161, Sub-section 11, of the Mining Act be deleted and the Section read as follows:-

"No building for thawing explosives shall be maintained in connection with any mine except with the written permission of the Inspector of Mines. The site of this building and the style of structure and equipment shall be subject to the approval of the Inspector. The building shall be under the direction of the manager or some person authorized by him. The quantity of explosives brought into any thawing house at any one time shall not exceed the requirements of the mine for a period of twenty-four hours, plus the amount that it may be necessary to have thawing to maintain that supply."

4. That all underground structures necessary for the installation, maintenance and repair of machinery and equipment should be fire proofed.

Digitized by Google

5. That all fans except "Booster" fans should be placed on the surface and be reversible, and all underground fans should be in fire proofed housing.

6. That oil and grease kept underground be contained in suitable metal receptacles and should not exceed one week's supply.

7. That there should be a sufficient number of fire doors at every station where practicable, so that the shaft could be completely cut off from the rest of the mine.

8. That all inflammable waste or rubbish should be taken to the surface.

9. That shift bosses and mine captains should certify at least once a week that there is no accumulation of combustible waste or rubbish underground, except as noted, in the area under their supervision.

10. That rescue stations be located at a place selected by the Chief Inspector of Mines in the Timmins, Kirkland Lake and Sudbury mining areas, and be in charge of one man to be appointed by and under the control and direction of the Department of Mines. It should be the duty of such employee to take care of the apparatus, train men in the mines in his area in rescue work and inspect and report upon the apparatus, if any, maintained at any such mine.

11. That each rescue station should contain the following or other equipment to be ultimately determined:-

1	Tool Chest.
15	Oxygen cylinders - 100 cubic feet each.
1	Portable Orsat apparatus for making analysis of mine air.
1	Anemometer for measuring ventilation.
1	Psychrometer for determining humidity of mine air.
1	Maximum and Minimum thermometer.
2	Cabinets (first aid) with extra bandages and splints.
4	Canaries for testing mine air for carbon monoxide.
2	Stretchers.
12	Self contained oxygen breathing apparatus with accessories for testing, repairing and recharging.
1	Pyrotannic acid detector for determining carbon monoxide in blood and air.

Digitized by Google

5 All-service gas masks with extra canisters.
1 Iodine pentoxide detector for indicating amount of carbon monoxide in the air of the mine.
1 Geophone.
1 Oxygen inhaler for administering oxygen in conjunction with artificial respiration.
1 Oxygen pump for re-charging small tanks for breathing apparatus.
1 Lifeline 1200 feet used for rescue crews when exploring mines after fires or explosions.
12 Electric cap lamps with accessories and charging equipment.
12 Approved-type flashlights.
20 Bottles for collecting samples of mine air.
Cardoxide.

The above equipment was suggested and put before the Commission by the Chief Inspector of Mines at the inquiry held at Haileybury. He was not then able, however, to definitely say it should be adopted in its entirety. It should be at once reviewed by the Inspector and the Committee representing the operators and finally determined. The equipment adopted should be used in all stations so that there would be uniformity.

12. That fire protection systems be installed at all underground crushers, tipples and in dry shafts.

13. That for the purpose of a uniform danger alarm all mines in Ontario should have equipment for pumping into air lines a stench chemical to be selected and adopted by the Chief Inspector of Mines.

14. That readable signs showing the way to emergency exits should be posted in prominent places underground and all men should be instructed where these emergency exits are placed.

15. That the Chief Inspector of Mines may order an underground connection be made between adjoining mines where he deems it necessary for the safety and protection of underground employees.

"This proposed regulation invades the right of ownership, may involve an expense largely for the benefit of an adjoining property and otherwise open up contentious questions. While I deem it expedient to recommend it as a safeguard in a remote but possible contingency, there should be a proviso allowing the right of appeal from the order of the Inspector to a person or tribunal to be decided upon.

Digitized by Google

Gases Encountered In Metal Mines

During the year it has been amply demonstrated that metal mines continue to encounter numerous dangerous gases; in fact, metal mines appear to have by far a greater variety of dangerous gases than are to be found in coal mines, notwithstanding well-defined opinion to the contrary.

In the Mining Magazine of London, issue of August, 1928, there is an abstract of an article entitled "Natural Gas in Mines on The Rand," and the following tabulation taken from that abstract gives some analyses by the Government Laboratory of South Africa of gases found in the City Deep, Robinson Deep, and Crown mines, all famous for gold production.

	Crown Mines, %	Robinson Deep, %	City Deep, %
Hydrogen	77.5	15.4	24.0
Methane	11	55.2	5.0
CO_2	0.1	0.2	- -
Oxygen	0.3	6.0	- -
Inert (Nitrogen etc)	11.1 (difference)	- -	- -
CO	- -	Nil	Nil

The gases tabulated are of particular interest because of the exceptionally large percentage of hydrogen in all of them, but particularly in the one from the Crown mines. The combination of methane and hydrogen gives a decidedly inflammable mixture, and it is fortunate that large quantities of these gases are not found.

These gas occurrences are described in more detail in the following abstract taken from pages 67 and 68 of the 1927 Annual Report of the Government Mining Engineer of The Union of South Africa:

> Three occurrences of inflammable gas in workings at great depths were reported during the year from the City Deep, Robinson Deep and Crown mines respectively. They indicate that an unexpected form of danger is to attend future deep mining on the Central Rand, but whether or not it is to be one of great importance remains to be seen. According to present indications the ventilation of the lower levels necessary to dilute and carry away the dust thrown into the air by mining operations and to cool the workmen will be sufficient, except in rare cases, to deal with the gas encountered.
>
> In the City Deep on 9th November, 1926, inflammable gas was found issuing from a shot-hole socket in a winze below the thirty-second level, No. 4 (a) shaft, at a depth of about 6,746 feet below the surface. The gas caused bad headaches, and, when lighted, burnt strongly with a blue flame.

Digitized by Google

It is reported to have shown, on qualitative analysis, the presence of carbon monoxide and methane.

In another winze on the same level, but 325 feet away, a greater volume of gas was encountered on 18th February, 1927. The gas, which bubbled up on the footwall side of the winze, burnt with a strong blue flame. Analysis of a sample gave 24 per cent hydrogen, 5 per cent methane, and carbon monoxide, nil.

Both these occurrences in the City Deep were in shale below the reef horizon. The first was 460 feet and the second 280 feet distant on the normal from the Leader.

In the Robinson Deep on 20th September, 1927, gas was found issuing from a shot-hole socket in the face of 4,400 East Drive, Alma shaft. When ignited it burnt with a flame about 18 inches long, the flame being yellow tinged with blue. Analysis showed the gas to contain methane, 55.2 per cent; hydrogen 15.4 per cent; oxygen 6 per cent; carbonic acid 0.2 per cent; and carbon monoxide, nil. The place of occurrence is in quartzite 5,341 feet below the surface, at an unknown distance, probably about 50 feet normal, below the Leader, and about 280 feet normal above the bed of shale in which the City Deep occurrences were found.

In the Crown Mines on 18th November, 1927, a small explosion burnt two natives who were working a machine drill in the face of No. 29 Haulage, East Drive, No. 15a shaft. The gas continued to issue from the hole they had been drilling, and to burn with a roaring flame 5 to 6 feet long. It continued to burn till 24th November, the flame having then diminished to a few inches in length. A sample of the gas taken on that day gave an analysis, methane 11 per cent, hydrogen 77.5 per cent, carbon dioxide 0.1 per cent, oxygen 0.3 per cent, and inert gases (nitrogen, etc.) 11.1 per cent. Carbon monoxide and olefines were absent. When work was continued, with precautions, inflammable gas continued to be found issuing from various drill holes and slips in the rock for several days. The place of occurrence of the accident was in quartzite about 4,675 feet below the surface, about 230 feet normal below the Main Reef Leader, and about 140 feet normal above the shale bed.

It seems to be generally assumed, as is not improbable, that the inflammable gas has its origin in the shale bed, though only the occurrences at the City Deep were actually in that shale.

The large percentages of hydrogen found on analysis are remarkable.

No occurrences of inflammable gas have yet been reported from the Village Deep, which is noteworthy, as that mine lies between the Robinson Deep and the City Deep, and has extensive development workings below the Main Reef Leader at depths considerably exceeding that of the occurrence in the Robinson Deep, and slightly exceeding those of the occurrences in the City Deep.

Digitized by Google

A novel gas occurrence in some Colorado oil wells is described in the National Petroleum News issue of July 18, 1928, in which a gas, mainly carbon dioxide, was encountered in enormous quantities and under enormous pressures. One well yielded approximately 40,000,000 cubic feet of the gas per day, and the pressure was so great that it was impossible to keep drilling tools in the well in order to drill deep enough to reach the desired oil strata, supposed to be some hundreds of feet deeper. The gas on escaping absorbed so much heat that practically everything would soon be frozen solid near the top of the well or in the region for hundreds of feet below the top. These frozen bridges at times "let go" or are made to "let go" by drilling with the usual tools; but when the release occurs it is stated that "the tools, or bailer, or whatever happens to be in the hole leave for other parts, and so does the crew." So far as known, this gas has not yet been put to any useful purpose.

During the year a fire occurred due to methane ignition in a wet shaft, part of the Hetch Hetchy water project, near San Francisco; notwithstanding the extreme wetness of the shaft, methane "feeders" which had become ignited continued to burn and finally ignited some of the timber; the flames were later extinguished, however, without loss of life. Partly as a result of this affair the following orders were issued by the California Industrial Accident Commission in October, 1928:

1. Adequate ventilation shall be provided at all times in all underground workings in order to prevent explosive gases from collecting.

2. No open lights, smoking, matches or smoking material shall be allowed in underground workings. A large notice to this effect shall be posted in plain view at each headframe and portal.

3. Lighting conductors underground shall conform to Orders 713-7 (h) and (i) of the Electrical Safety Orders of the Division of Industrial Accidents and Safety.

4. Immediately before shooting, tests of the air with a flame safety lamp of a type approved by the United States Bureau of Mines shall be made by a competent, designated person, and if the presence of explosive gas is indicated by this lamp, no shots shall be fired until the workings are free from gas. Men shall not be allowed to go to work after blasting until tests have been made, and the workings found to be free from all gas.

   Whenever the tunnel operations are not continuously prosecuted, immediately before resuming work, a test of the air shall be made with the flame safety lamp, and the men shall not go to work until the underground workings are found free from gas.

Digitized by Google

5. If, for any reason, ventilation should be interrupted, continuous tests of the air shall be made, and if the presence of explosive gas is indicated by the flame safety lamp, then all men shall be removed to the surface until such time as ventilation has been restored, and no presence of gas is shown by the safety lamp.

All men shall be removed to the surface in instances where the ventilation has been interrupted for more than sixty minutes and not returned to work until the flame safety lamp shows that no gas is present.

6. A ladder of sufficient length shall be provided in each heading for the man making tests, so that he may be able to test the air throughout the workings.

7. These orders shall not apply to those men specifically designated to make gas tests, restore ventilation or perform other emergency operations under proper supervision.

The foregoing orders constitute an official recognition of the necessity in tunnel work of taking definite precautions against the gas ignitions which have so frequently occurred in tunnels being driven for water, sewer, or other purposes in or adjacent to our large cities. The orders should be extended to include prohibition of bare power wires, open types of electrical switches or electrical pumps, locomotives, etc., in any tunnel where carbonaceous shale, slate, etc., or coal seams may be encountered; strata of this kind, especially when below the water level, are very likely to give off explosive gas and in some instances poisonous gases such as hydrogen sulphide.

Sealed fires, usually of spontaneous origin, from time to time give trouble in some of the iron mines of Michigan where carbonaceous shales or slates have been encountered. These fires are difficult to handle, and the general practice is to attempt to seal the affected region; occasionally, however, the seals break or become crushed and thus release the gases from the sealed regions so that the air of surrounding workings becomes contaminated. The escaping gases frequently contain appreciable percentages of the actively poisonous hydrogen sulphide and of the somewhat less dangerous sulphur dioxide, with carbon dioxide in the amount of 5 per cent or over and oxygen reduced to 12 per cent or less. In some instances high temperatures are found, but the temperature is usually less than 200° F.

CONCLUSION

Although our metal mining people are slow to realize the benefits of ventilation, there are occasional indications that at least some of our wide-awake operators realize the benefit of expending a reasonable amount of time, attention, and money in the effort to secure adequate air circulation in their mines and definite control of that circulation. C. F. Kelley, president of the Anaconda Copper Mining Co., in 1928 made the following statement:

Digitized by Google

I can remember when members of our staff said the final limit of this operation will not be the continuity of mineral content but the impossibility of ventilating and securing air under which men can live; I can remember when the budget was put up $3,000,000 to ventilate the Butte mines in a single lump. Had it not been for the organization that could carry that through upon a unified system, this operation would cease to exist.

Inasmuch as the Anaconda Company continues to ventilate and even to expand in its ventilation work, it is fair to assume that this company has learned pretty definitely that ventilation pays.

The following paragraph occurs in a paper by A. C. Butterworth, electrical engineer, mining department, Pickands, Mather and Co., presented before the American Society of Mechanical Engineers at St. Paul, Minn., in August, 1928:

Partly because of a growing consciousness of the average unsatisfactory air conditions underground, more and more attention is being paid to the question of mechanical ventilation of the mines. There is not the necessity of getting rid of explosive gases which exists in some coal mines, but the heat and the carbon dioxide due to decaying timber matting, together with the powder smoke underground, make it necessary to pay attention to this problem. In the early days many mines had reasonably good natural ventilation, but with the increased depth of mining even those mines are now turning to mechanical ventilation. Many devices have been tried out to improve local ventilation in exceptionally poor places. Direct blowing of compressed air and the use of air "injectors" and air-operated fans and blowers have generally given way to the use of the latest type of portable motor-driven ventilating fans. The trend of this work, however, is toward the large mine-ventilating unit, together with a proper system of air doors throughout the mine, to give adequate and positive ventilation everywhere in the mine. At some mines it is found necessary to operate these big fans only occasionally, but sometimes conditions make it necessary to run them continuously; and without question, considerably more power can be used to good advantage for this purpose in most underground mines in this territory. Although no comparative figures are available, it stands to reason that fresh air will keep the mining efficiency higher than if the air were hot and dead, as is frequently the case at present. At one property operated by Pickands, Mather & Co., where the fan is used continuously, the power consumption is about 1 kw.-hr. per ton; and, as expressed by the underground men, 'this fan is worth a million dollars.'

One of the mine operating officials of Pickands, Mather & Co. expresses his opinion as follows:

Digitized by Google

The principal advantage of mechanical ventilation to the operator has been the increased efficiency of the miners and in the saving of time to the men thru being able to return to his working place in a shorter time after each blast.

With the improved condition underground, it is easier to maintain a full force at all times. For example, the average temperature was reduced about four degrees and the relative humidity lowered between 3 and 4 per cent. The more rapid removal of smoke and gas has helped considerably, but no doubt the greatest benefit has been derived thru lower temperatures and reduced humidity. In some places where the temperature was lowered only one or two degrees, the rapid moving air made working conditions more comfortable and have resulted in a more efficient operation. This improvement in working conditions has materially increased the efficiency of the miners thru a saving in time to the miners by the quick removal of smoke and gas and a marked reduction in temperature and relative humidity.

J. B. Pullen, ventilation engineer of the Phelps Dodge Corporation, in a paper in The Mining Congress Journal for September, 1928, describes ventilation practice in the Phelps Dodge mines at Bisbee, Ariz., and concludes as follows:

It is impossible to show in dollars and cents just what benefits the company has derived from the installation of mechanical ventilation. Nevertheless it is a recognized fact that certain sections of the mine could not be worked without it. Also, by bringing about such improved conditions it is natural to assume that the efficiency of the underground men must have increased to some extent. Aside from this, good working conditions will attract good men, making it easier to build up a productive organization. This alone is certain to have a favorable effect on costs.

In concluding this report, it seems desirable to call attention to the fact that many interesting points have been brought out in a paper by O. A. Glaeser[3] concerning the ventilation of the United Verde mine at Jerome, Ariz. There is no question that the ventilation system in the United Verde mine is one of the best to be found in metal mining.

---

3 Proceedings of the February, 1929 meeting of the American Institute of Mining and Metallurgical Engineers.

* * * * * * *

Digitized by Google